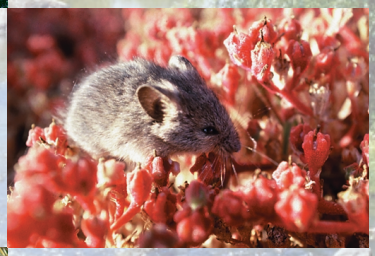
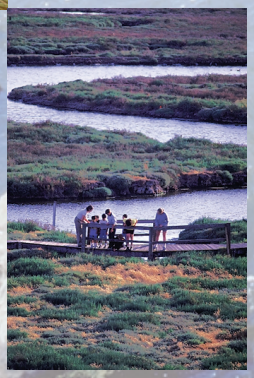
South Bay Water Connections

Environmental Education
Classroom Activities for Grades 6-8





CITY OF
SAN JOSE
CAPITAL OF SILICON VALLEY

Environmental Services

1.1 A SIMPLE DROP OF WATER

Objective:

This demonstration helps students to visualize the available water supply on earth.

Materials:

- one 1000 ml (1-liter) container
- one 100 ml and one 10 ml graduated cylinder
- one ice tray
- one eyedropper
- one metal can
- one salt shaker with table salt

California Content Standards:

Science, Grade 6

Different natural energy and material resource, including air, soil, rocks, minerals, petroleum, fresh water, wildlife, and forests, and classify them as renewable or nonrenewable. (Resource 6b)

Construct appropriate graphs from data and develop qualitative statements about the relationships between variables. (Investigation and Experimentation 7c)

PROCEDURE

1. Show the class a liter of water, and tell them it represents all the water on earth. Ask them where water is found. *Oceans, rivers, groundwater, glaciers, etc.*
2. Pour 30 ml of the water into a 100 ml graduated cylinder. This represents earth's fresh water, about 3% of the total water. Put salt into the remaining 970 ml to simulate water found in oceans, unsuitable for human consumption and domestic use.
3. Almost 80% of earth's fresh water is frozen in ice caps and glaciers. Pour 6 ml (20% of the 30ml) of fresh water into a 10 ml graduated cylinder and place the rest (24 ml) in an ice tray. The water in the 10 ml graduated cylinder (about .06% of the total) represents non-frozen fresh water. Only about 1.5 ml of this water is surface water; the rest is *groundwater*.
4. Use an eyedropper to remove a single drop of water (.05 ml). Release this one drop into a small metal can. Make sure the students are very quiet so they can hear the sound of the drop hitting the bottom of the can. One tenth of this drop represents clean, fresh water, which is not polluted or otherwise unavailable for use, about .00003% of the total! This precious part of a drop must be managed properly.
5. Discuss the results of the demonstration. At this point many students will conclude that a very small amount of water is available to humans. However, this single drop is actually a large volume of water on a global scale.

EXTENSION

1. Based on the demonstration, have students graph the relative amounts of usable to unavailable water supplies. Also, have them write a description of the relationship between the usable and unavailable water supplies.
2. Take a class field trip to the Rinconada Water Filtration Facility to learn about drinking water treatment. One-hour tours are available for grades 4 - 8 from December through March. Call the Youth Science Institute at (408) 356-4945 x12.

1.3 WATER USE AUDIT

PREPARATION

To introduce the lesson, distribute the reading, *How Much Water is Used at Home.* After they read it, discuss with the class why water conservation is important at home and at school and what they can do to save water.

PROCEDURE:

1. Make the measuring tools. Assign groups of students to make one graduated bucket per group. Put known amounts of water (one liter or quart) into the one-gallon bucket or plastic container and mark the level on the outside with a permanent marker. Add another measured portion and mark again. Repeat until another complete liter or quart cannot be added without overflowing the sides. Label each mark with the units (quarts or liters).
2. Assign each group of students to use their graduated bucket to measure the water used by one of the following activities. More than one group can do the same activity. Some activities use water conservation techniques and others do not. (If groups are same sex, bathroom sinks can be used.) Simulate the following activities and estimate to the nearest half-liter or quart:

Objective:

Students will learn to gather, organize, and manipulate data, make estimates based on that data, and determine the most feasible ways to conserve water.

Materials:

(for each student group)

- one-quart (or one liter) container
- one-gallon plastic ice cream tub or other large wide-mouth container

California Content Standards:

Mathematics, Grade 6

Convert one unit of measurement to another (e.g., from feet to miles, from centimeters to inches). (Algebra and Functions 2.1)

Science, Grade 6

Different natural energy and material resource, including air, soil, rocks, minerals, petroleum, fresh water, wildlife, and forests, and classify them as renewable or nonrenewable. (Resource 6b)

Select and use appropriate tools and technology to perform tests, collect data, and display data. (Investigation and Experimentation 7b)

Washing hands — with *water on* throughout the washing

Washing hands — with *water off* while scrubbing hands

Brushing teeth — *water running* while pretending to brush teeth. (This can be done without a real toothbrush. But the duration should be their estimation of how long it really takes.)

Brushing teeth — *water off* while brushing, *on* only to wet brush and rinse.

Toilet flushing — Have group check school toilet and see if it indicates the amount of water it uses per flush. (In the following calculations, one group can use the 1.6 gallons per flush for an ultra-low flush flow toilet and another can use 5 gallons per flush for an older toilet.)

3. In large print on a large sheet of paper or the chalk board, create a table similar to the chart below.
4. Convert volumes to gallons (3.785 l = 1 gal; 4 qts. = 1 gal).
5. Have each group figure the average frequency the members of their group do their assigned activity. For example: Do they wash their hands 4 times per day on average? Do they flush a toilet 6 times per day? This average will be used to represent the average usage in the South Bay.
6. Ask each group to multiply the volume used in gallons, times the frequency per day for one person, times the population (1.4 million) served by the Water Pollution Control Plant. This gives them the amount of water that would flow into the Bay everyday.
7. Each group should post their totals in large print on the class chart using appropriate materials (i.e. Post-Its, chalk, markers, index cards, sheets of paper, etc.).
8. With the class, extrapolate the volume of water that would be conserved and kept out of the Bay everyday if everyone changed from non-conserving practices to conserving practices.

EXTENSIONS

1. The water use audit can be used to question assumptions: Do all people leave their faucets on while they brush their teeth? Do all people wash their hands the same number of times? Have students record their estimates at the start of their measuring activity, then compare individual estimates within their group. To begin the discussion, have a reporter in each group tell the class how close their group came to a consensus on an estimate for one activity.
2. Have students conduct a study of toilet flushing at school. Announce the project to the student body. Place a chart in each restroom for a week. Have students and faculty mark on chart each time they flush the toilet. Tabulate results after a week. Calculate how much water was used and how much could have been saved by switching to an ultra-low flush toilet (ULFT). Call the water company serving your school, and ask how much it costs the school per gallon of water. Using the data collected, have the class write letters to lobby the school administration about the benefits of retrofitting restrooms with ULFTs.

Activity	Gallons used	Frequency per day	Population	Daily Flows to Bay (gal)
Toilet Flushing	0.4	6	1,400,000	(.4) x (6) x (1,400,000) = 3,360,000
Washing Hands			1,400,000	
Brushing Teeth (tap on)			1,400,000	
Brushing Teeth (tap off)			1,400,000	

1.7 SUFFOCATING FISH

Objective:

- To know what problems might occur if oxygen decreases in a body of water.
- To model what happens in a situation where decomposition is occurring.
- To obtain, organize, graph, and interpret information.
- To interpret results in terms of variables.

Materials:

(for teacher to make yeast suspension)

- highly active dry yeast (available at grocery stores)
- sugar
- 200 ml beaker
- thermometer
- hot plate or microwave oven

(for each student group)

- pre-made yeast suspension
- milk or cream
- 0.01% methylene blue in dropper bottle
- distilled water
- 6 test tubes
- stop watch or watch with a second hand
- 3 - 5 ml pipettes
- test tube rack
- copies of Student Procedures
- graph paper

California Content Standards:

Science, Grade 6

Over time, matter is transferred from one organism to others in the food web, and between organisms and the physical environment. (Ecology 5b)

California Content Standards:

The number and types of organisms an ecosystem can support depends on the resources available and abiotic factors, such as quantity of light and water, range of temperatures, and soil composition. (Ecology 5e)

Develop a hypothesis. (Investigation and Experimentation 7a)

Select and use appropriate tools and technology to perform tests, collect data, and display data. (Investigation and Experimentation 7b)

Construct appropriate graphs from data and develop qualitative statements about the relationships between variables. (Investigation and Experimentation 7c)

Recognize whether evidence is consistent with a proposed explanation. (Investigation and Experimentation 7e)

Science, Grade 7

Select and use appropriate tools and technology to perform tests, collect data, and display data. (Investigation and Experimentation 7a)

Communicate the logical connection among hypothesis, science concepts, tests conducted, data collected, and conclusions drawn from the scientific evidence. (Investigation and Experimentation 7c)

Science, Grade 8

Evaluate the accuracy and reproducibility of data (Investigation and Experimentation 9b)

Distinguish between variable and controlled parameters in a test. (Investigation and Experimentation 9c)

Construct appropriate graphs from data and develop quantitative statements about the relationships between variables. (Investigation and Experimentation 9e)

BACKGROUND

If water supplies contain materials which rot or decompose, dissolved oxygen, present in the water, is used up. Decay and decomposition require vast supplies of oxygen. The use of dissolved oxygen by bacteria for decay of wastes may be a life or death occurrence for organisms such as protozoa or fish. They need dissolved oxygen to live.

In this investigation, methylene blue indicator is used to follow the depletion of dissolved oxygen in a water supply.

When oxygen is present and methylene blue is in its oxidized state, it is blue in color. When sufficient oxygen is no longer available, methylene blue becomes reduced and it is colorless. This reaction enables the investigator to determine when oxygen decreases below a critical concentration.

Methylene Blue	color	indication
	blue	oxidized
	colorless	reduced

Yeast is a decomposer in this lab. Milk is the "waste" which decays.

Note: The reactions for this experiment take time, ranging from 3 to 4 minutes for the 100% milk solution to 10 to 15 minutes for the 10% milk solution. The 0% milk solution will have a slight color change after 15 minutes, due to the presence of the sugar. A complete color change of the 0% milk solution, from blue to colorless, will take substantially longer.

Preparation of solutions

- *Yeast Suspension*: 1 package of dry yeast added to 100 ml of distilled water. Prepare yeast solution 10 minutes before students need it. Heat 100 ml of distilled water to 110 - 115°F. Add 1 teaspoon of sugar to heated water and stir well. Once sugar is dissolved, add 1 package of highly active yeast (1 package = 2¼ teaspoons of yeast) to sugar and water mixture. Stir well, and keep stirring until the solution foams quite a bit. For best results, try to use the yeast within 30 minutes of preparation. (Fleishman's Rapid Rise Highly Active Yeast works particularly well.)
- *Methylene Blue*
  Powder Form: Mix .01g dry methylene blue with 100 ml distilled water.
  Liquid Form: Methylene Blue can also be purchased as a liquid from pet stores. Most liquid versions come in 1% solutions. To make a .01% solution, dilute 1 ml of 1% methylene blue in 100 ml of distilled water.
- *Milk:* Purchase whole milk, cream, and milk with 2% or 1% fat. Make sure milk or cream is room temperature or warmer. Different groups should study different kinds of milk.

PROCEDURE

1. Distribute Student Procedures worksheet, graph paper and materials to each work group.
2. Explain the role of the yeast and the milk in this experiment.
3. Discuss the results of the experiment with the class. *Chart 1 shows the concentrations of milk and water in each of the six test tubes.*

Chart 1

Test Tube	Concentration	Milk (ml)	Water (ml)
#1	100%	5	0
#2	50%	2.5	2.5
#3	33%	1.65	3.35
#4	20%	1	4
#5	10%	0.5	4.5
#6	0%	0	5

Chart 2

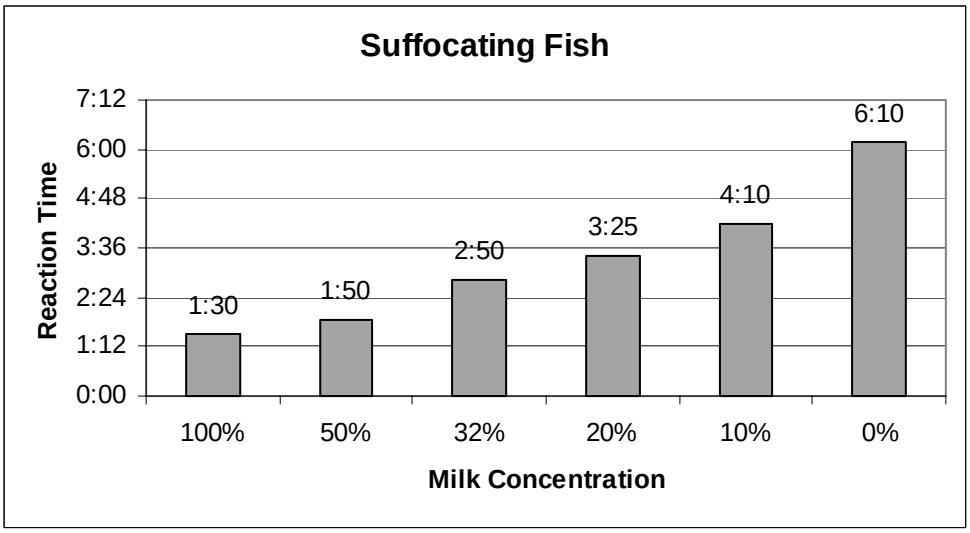


Chart 2 shows a sample plot of the reaction vs. the milk concentration of the test tubes.

4. Ask them to hypothesize what effects dissolved oxygen depletion in a creek may have on fish.

Student Procedures

Each group should:

1. Obtain and label 6 test tubes. Prepare 5 ml of milk/water solutions at the following concentrations and place in the corresponding tube. (The first two amounts have been done for you. You calculate the remaining ones.) Write the concentrations on the test tube labels.

Test Tube	Concentration	Milk (ml)	Water (ml)
#1	100%	5.00	0.00
#2	50%	2.50	2.50
#3	33%	1.65	
#4	20%	1.00	
#5	10%	0.50	
#6	0%	0.00	

2. Using the dropper bottle, add 12 drops of .01% methylene blue into each of the test tubes. Swirl test tube. Each test tube should be blue in color.
3. Assign one team member to be the timer. Another should transfer the yeast to the milk solution. Using a pipette, add 5 ml of the yeast suspension to test tube #1. The timer should signal the add point by a countdown (e.g. 5 - 4 - 3 - 2 - 1 - *Add*) and should start the stopwatch when the yeast is added to the test tube. Continue to time the reaction until the solution changes color. All solutions should change from a bluish color to white, except for test tube #6. Record the time in the end column.

Test Tube	Milk Concentration (%)	Reaction Time (minutes)
#1	100	
#2	50	
#3	32	
#4	20	
#5	10	
#6	0	

4. After the reaction in test tube #1 is completed, reset the stopwatch to zero. Using a pipette, add 5 ml of the yeast suspension to test tube #2. The timer should signal the add point by a countdown (e.g. 5 - 4 - 3 - 2 - 1 - *Add*) and should start the stopwatch when the yeast is added to the test tube. Continue to time the reaction until the solution changes color.
5. Continue to add 5 ml of the yeast suspension to each test tube, remembering to time the reaction and to reset the stopwatch to zero before moving to the next test tube. Record each reaction time in the end column.
6. Plot the reaction time (time for color change) on the Y-axis and concentration of milk on the X-axis. Interpret the graph. What is the relationship between the concentration of milk and the rate of yeast oxygen consumption?

3.4 SEMI-PERMEABLE MEMBRANES & REVERSE OSMOSIS

BACKGROUND

For indirect *potable* reuse, *recycled water* is purposely discharged into either groundwater or surface water to ultimately supply a public drinking water system. To ensure public health, recycled water that is used to augment a drinking water supply needs to receive a higher degree of treatment than for nonpotable applications. *Reverse osmosis* is a way of forcing wastewater (or saline) through a semi-permeable membrane through which the waste products (or salts) cannot pass. Reverse osmosis, though costly, is an effective water purification process that can be used to make Silicon Valley's recycled water supply fit for supplementing drinking water reservoirs. This experiment with vegetables shows how reverse osmosis can be used to purify salty water.

PROCEDURE

1. Divide class into small work groups, and give each student the worksheet entitled, *Passing Through*.
2. Provide enough materials for each work group to perform the experiment on the vegetables.
3. Discuss as a class the changes each group observed in the fresh vegetables and beans.
4. Discuss why the fresh vegetables became firm or the beans became larger and heavier, emphasizing the principle of osmosis.

Objective:

Students will learn how reverse osmosis allows only water to pass through a semi-permeable membrane.

Materials:

- large, plastic disposable cups (or *environmentally friendly* alternative), for each student
- squishy vegetable slices (soft cucumbers, potato, or any wilted vegetable) or dried beans
- ruler
- scale
- *Passing Through* student worksheet

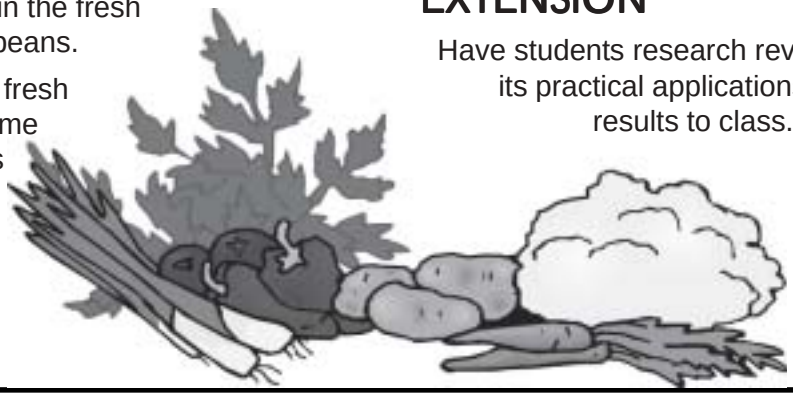
California Content Standards:

Science, Grade 7

Cells function similarly in all living organisms. (Cell Biology 1a)

EXTENSION

Have students research reverse osmosis and its practical applications and present their results to class.



Passing Through Worksheet

STUDENT PROCEDURES

Semi-permeable membranes, like plant cells, allow small molecules, like water, to pass through the membrane. *Osmosis* is the flow of water through a semi-permeable membrane until there is an equal concentration of a dissolved substance inside and outside of the membrane. When someone takes a long bath and ends up with wrinkly skin, this is the result of osmosis. Water in the bath equalizes the salt concentrations in the bath and skin cells by diluting the more salty skin cells.

Reverse osmosis is the process of forcing water the opposite direction osmosis would take it. As a result, the salty side gets saltier and pure water passes to the other side of the membrane. This unnatural forcing is accomplished by pumping water through the membrane.

How does this happen? Salt, or another contaminant, can be kept back while water passes through the membrane because of the difference between the size of the water molecules and the contaminants. If a water molecule were the size of a tennis ball, and the true size ratio were kept, a virus would be the size of a semi-truck and a bacterium would be the size of a pyramid. If a membrane is used that has small enough holes, even dissolved salt can be held back while the water molecules pass through. Purified water is the result.

1. Feel the vegetable slices and record how firm or squishy they are. Alternatively measure their length and width with a ruler and weigh them. Record the measurements on the chart for Day 1.
2. Place vegetable slices or beans into a cup.
3. Poor water into the cup to cover vegetable or beans.
4. Let experiment sit overnight.
5. Feel vegetable slices and note how firm or squishy they are. Measure the length and width of each slice and weigh them. Record the measurements on the chart for Day 2.

Day 1

Vegetable	Length	Width	Weight	Firmness

Day 2

Vegetable	Length	Width	Weight	Firmness

Name:_____ Class:_____ Date:_____

3.5 SELL IT, BABY!

Objective:

Students will be able to:

- Analyze and evaluate print advertisements.
- Develop a conceptual framework for mass communications.
- State at least one reason why recycled water is valuable.

Materials:

- *Recycled Water for the South Bay* Student Reading
- *South Bay Water Recycling* videotape
- *The Word from Outer Space* Student Reading
- magazine and newspaper advertisements
- *What's in an Ad?* worksheet template
- *Creative Brief* worksheet
- poster paper
- drawing supplies

California Content Standards:

English–Language Arts, Grade 6

Connect and clarify main ideas by identifying their relationships to other sources and related topics. (Reading 2.3)

Science, Grade 6

Over time, matter is transferred from one organism to others in the food web, and between organisms and the physical environment. (Ecology 5b)

The number and types of organisms an ecosystem can support depends on the resources available and abiotic factors, such as quantity of light and water, range of temperatures, and soil composition. (Ecology 5e)

English–Language Arts, Grade 8

Interpret and evaluate the various ways in which visual image makers (e.g. graphic artists, illustrators, news photographers) communicate information and affect impressions and opinions. (Listening and Speaking 1.9)

Deliver research presentations. (Speaking Applications 2.3)

BACKGROUND

Every day we are bombarded by radio and television commercials and magazine, newspaper, billboard, or Internet advertisements aimed at convincing us to buy a particular product or service. These ads are produced by marketing or public relations teams who research the needs and aspirations of a particular target audience, develop an advertising concept for a marketing campaign, do all the creative work to produce the advertisements, place the advertisements in the appropriate media, and analyze the effect of the marketing campaign on product sales.

Product marketing is but one application of marketing concepts. Social marketing supports the work of public and nonprofit agencies and political campaigns to promote ideas and causes in an effort to bring about social change. As an example, years ago people in California openly smoked wherever they wished. Now, after years of social marketing campaigns linking smoking and secondhand smoke to cancer and other health problems, smoking in most public places is banned in California as well as on domestic and international airplane flights. This change did not come about instantly, but over the course of many years. Mass media was used as a tool to convince the public of the connection between smoking and human health and to support legislators to enact laws to protect the public

good. Over the last 20 years, other social marketing campaigns have been conducted in California to help the public to understand: how AIDS is transmitted and may be prevented, why public schools need to be refurbished, and why voting for mass transit systems could alleviate traffic problems in the South Bay.

This classroom activity (which is best done over several class periods) provides students with an opportunity to learn the "real world skills" of marketing professionals by having them work in project teams to select a target audience, craft a message, and produce an advertisement promoting the potable reuse of recycled water. Although this application for recycled water is merely hypothetical at this time, it may become part of the South Bay's water future. After all, water is a limited resource. All of the water that we have ever had and ever will have on plant Earth is here now. It is only the availability that changes at any given time.

PROCEDURE

1. Prior to this activity, be sure that students understand the concept of reverse osmosis as introduced in *3.4 Semi-permeable Membranes and Reverse Osmosis*. You may wish to conduct the public opinion survey in *3.6 Public Opinion Survey* to provide "market research data" prior to doing this lesson on advertising.
2. Distribute the student readings, *Recycled Water for the South Bay* and *The Word from Outer Space*. Show the *South Bay Water Recycling* videoape to the class.
3. Divide the class into small work groups. Have them discuss two questions:
   - What are the pros and cons of using reverse osmosis on a large scale to meet the water needs of a community like Santa Clara Valley?
   - What might be some of the public's concerns about using recycled wastewater as part of the community's drinking water supply?
4. Share the different points of view as a class.
5. Explain to the class that each work group is going to become a marketing team that will produce an advertisement to convince people in Santa Clara Valley that recycled wastewater that has been treated through reverse osmosis.
6. Discuss with the class the difference between product marketing and social marketing.
7. You may wish to do the extension lesson with the class at this time.
8. As a homework assignment, have students look at print advertisements in magazines and newspapers. Using two ads that they find striking: one for a product and one for a public/social issue. Have them complete the *What's in an Ad?* worksheet for each ad. Also have them clip a copy or actual sample of each to the worksheet. (You may wish to have students bring in magazines or newspapers for classroom use a week or so in advance of the lesson.)
9. Have them share their findings in their work group. Ask them to discuss similarities and differences in marketing products vs. marketing ideas.
10. Give each group a copy of the *Creative Brief* worksheet and have them go through the steps of developing an advertising concept.
11. After sharing the briefs as a class, have each group develop the print advertisements. Let them divide the responsibilities among themselves of developing the ad copy, the layout, and the imagery. The ads should include a headline and possibly a campaign slogan as a tag line. They may wish to use computers, drawing implements, or clip images from magazines to develop their print advertisements. Have them do a rough draft before doing the final product. That way they can revise it after getting input from other groups, much as an ad agency would share several drafts with a client before developing final artwork.
12. Have each group make an oral presentation to the class on the development of its final work product.

Recycled Water for the South Bay

Did you know your body recycles water? Lots of it! Everyday our bodies recycle over 2.5 gallons of water. Our small intestines absorb that much into our blood stream. Our large intestines absorb a little more.

Nature recycles water too. In the water cycle, water evaporates and leaves impurities behind. And in the South San Francisco Bay area we now recycle the water we dirty everyday.

Recycling Water from Our Homes

The *wastewater* from our homes and business is treated to a high level of purity at the San Jose/Santa Clara Water Pollution Control Plant. After treatment the cleaned water flows through a large pipe into the south end of San Francisco Bay — *except for the portion diverted for recycling.*

By using *recycled water* for landscaping, irrigation, and industrial processes, we not only save *potable* water for more important uses, but we help *slow the flow* of fresh water to the Bay.

Treated wastewater is much less salty than Bay water. (Remember, water flows from the Pacific Ocean into San Francisco Bay. Ocean water is about 30 times saltier than treated wastewater.) When huge volumes of treated, fresh water flow from the Water Pollution Control Plant into the Bay every day, the overall effect may cause harm by diluting the salt marshes of the South Bay.

Recycled Water, a Valuable Resource

South Bay Water Recycling is a system of pipes and pump stations that carries treated *effluent* from the San Jose/Santa Clara Water Pollution Control Plant to schools, parks, and businesses. *Recycled water* is used for landscape irrigation, cooling towers (which cool buildings or equipment), and some industrial processes. Even in its present limited use, recycled water saves *potable* water supplies for more important uses than watering plants and lawns. This recycled water supply is already of high enough quality to be used for indirect potable use through *groundwater recharge*, already a long-standing practice in California. One day, additional treatment through *reverse osmosis* may make our recycled water supply fit for supplementing drinking water reservoir supplies.

Maintaining Recycled Water Quality

The key to high quality, recycled water is the effectiveness of the wastewater treatment process. The San Jose/Santa Clara Water Pollution Control Plant removes most of the *organic wastes* that would be harmful to the Bay if there were no treatment plant. Depending on what toxic substances enter the Plant, their removal is complete or partial.

Some pollutants are removed completely, like soaps. (Even biodegradable soap is toxic to aquatic life if it is not treated.) Some pollutants, like some organic liquids, are only partially removed. Others pass through the treatment process unchanged, like some tightly bound toxic metal compounds.

Laboratory technicians at the Water Pollution Control Plant constantly test the wastewater at different stages in the process. Through each stage of the treatment process, the wastewater (called *effluent*) is tested to make sure that the processes are working properly.

Once the *effluent* has undergone the primary, biological nutrient removal, filtration, chlorination, and dechlorination processes, it is ready to be discharged into the Bay or recycled. At this point, laboratory staff tests the water again by flowing it through a large fish tank. It is critically important that fish and wildlife are protected from any toxins.

Recycled Water Uses

Instead of being released to the Bay, about 10% of the Water Pollution Control Plant *effluent* is be piped to parks, schools, businesses and farmlands as a drought-proof water supply. The water is used to irrigate landscaped areas, farmlands and by industry to manufacture products. Some local *recycled wate*r users include: Lick Mill Park, Santa Clara Golf and Tennis Club, the 49ers Training Camp in Santa Clara, Andrew Hill High School, Burnett Middle School, Kelley Park, Santa Clara County Fairgrounds, Municipal Stadium, and San Jose State University. Your school may be one of the sites that will soon be using recycled water.

You can see where recycled water is used for irrigation because there are purple signs and water meter boxes. If you shop in the McCarthy Ranch area in Milpitas, you will see the signs and boxes outside restaurants and stores.

Since recycled water is currently not yet treated to potable standards in the Santa Clara Valley, it is not used for drinking or bathing. Recycled water is delivered through pipes that have been separated from drinking water lines.

In some communities, though, recycled water goes through additional treatment processes to purify it to potable standards. The water is then used to supplement the groundwater and reservoirs water supplies. That water, is treated, then distributed to homes and businesses. This is called *indirect potable reuse*.

While this technology has been proven through studies and in practice to be completely safe, the public still has a difficult time accepting the notion of drinking purified wastewater. Most people do not understand that all water is already used countless times, then naturally recycled and treated in the *hydrologic cycle* before being consumed.

The Scoop on Heavy Metal

You might think that if metals were bad for the Bay they would also be bad for other parts of our environment. Most of these same toxic metals, when found in drinking water, or vitamin and mineral tablets, are considered essential for good human nutrition. There are two factors that combine to cause too many of these metals to be harmful to the Bay.

1. Because the South Bay is constricted by salt ponds, tidal flushing does not remove pollution well.
2. Bay life is much more sensitive to toxic metals than humans are and trace amounts these metals may concentrate in the bodies of *aquatic* creatures through the process of *bioaccumulation*.

The Word from Outer Space

In preparation for long space flights (like one to Mars), astronauts have tested systems that recycle their wastewater — even their urine! For 90 days, astronauts in an enclosed test chamber treated their wastewater from laundry, shower, hand washing, oral hygiene and urine and reused it — even for drinking. This test was conducted at NASA's Johnson Space Center in Texas. While inside the test chamber, one of the crew answered questions on how the wastewater was treated.

Some of the processes described are similar to those used at the wastewater treatment plant here in Alviso. For example, the treatment plant's biological treatment process uses the same principles as the astronaut's bioreactors to biologically remove organic carbon and ammonia from the wastewater.

The following reply is excepted from a letter written by crew member Nigel Packham to answer a university professor's questions about the astronauts' use of *recycled water*.

October 7, 1997

Dear Professor Blatchley,

…Phase III utilizes a unique "hybrid" water recovery system. Wastewater from the crew, made up of humidity condensate,[1] wash water (shower, hand wash and laundry water) and urine (not pretreated), is sent to a common feed tank. It is then processed through two bioreactors[2] in sequence, first through an immobilized cell bioreactor, which removes most of the organic carbon, and then through a trickling filter bioreactor where ammonia (from the breakdown of urea) is converted to nitrate and nitrite… — easier compounds to remove than ammonia.

Effluent from the bioreactors is then treated by a reverse osmosis system…. We use seawater-type membranes, 4.5 inches in diameter, 40 inches long (spiral-wound). We obtain ~85% recovery…. The remaining 15% (high salt-content brine) is treated by an air-evaporation unit, which loads the brine onto a wick,[3] blows hot air across the wick, leaving the salts behind, and, using a condensing heat exchanger, recovers the water to about 99.9% mass closure.

[If the reverse osmosis used by these astronauts is added to our existing wastewater treatment, our water could be mixed with the water in our reservoirs for potable use.]

Effluent from the reverse osmosis system has approximately 1-2 parts per million[4] total organic carbon[5]. Final polishing of the product water is performed by using a commercial water purifier (ion exchange and activated charcoal beds). After passing through beds which impart 2-4 parts per million of iodine into the product water as a residual biocide (germ killer), water is stored in 4 potable water tanks.

Potable water quality is defined by NASA…. Two common factors we use are (1) total organic carbon, which has to be less than 500 parts per billion, and (2) microbial content (the second part of your question).

To date in Phase III, we have produced water that has met all requirements for potability. In check-out testing, the major water isolates (which can be observed if there is insufficient contact time with the iodine), have been pseudomonas sp. — all non-human pathogens.

I hope this answers your questions. If not, please write back and I will put you in touch with our bioreactor experts.

Best wishes,
Nigel Packham [crew member]

Endnotes

[1] *Condensate* is water that comes out of air when it touches something cold, for example, the moisture that appears on the pane when you breathe on a cold window.

[2] *Bioreactors* are small systems for a space ship in which microbes react with and decompose wastes in wastewater — like mini wastewater treatment tanks.

[3] *Wicks* convey liquid by capillary action. A candle wick draws melted wax to the flame.

[4] *Parts per million* are very, very small. If you used parts per million to measure distance, two parts per million would be two large steps out of a million large steps. A million large steps would take you from San Jose to Mexico.

[5] In wastewater, *organic carbon* is the carbon that comes from living things like human wastes.

What's in an Ad? Worksheet

1. What is the headline (title) of the advertisement?

2. Who is the target audience? (Whose attention is this advertisement meant to attract?)

3. What's the message of the advertisement? (What is really being communicated both visually and verbally? What is the essential concept that the reader will remember after the ad is seen?)

4. Why or why not is this advertisement effective? (Things to consider: Do the visual and verbal elements support each other? Do they command your attention? If so, what is striking? Is the tone of the message appropriate for the audience?)

Name:_____ Class:_____ Date:_____

Creative Brief Worksheet

BACKGROUND

The year is 2020. Santa Clara County's population has grown to over 3,500,000. The community is now in its fifth year of a major drought. Residents and business have been asked to do all they can to conserve water. The South Bay Water Recycling system already diverts over 12,000,000 gallons of treated *wastewater* from the Bay each day for use in landscaping, crop irrigation, and industrial processes. The local water district, which is responsible for bringing adequate supplies of drinking water into the community, has proposed that 50% of the treated wastewater from the Water Pollution Control Plant be purified through a *reverse osmosis* process to meet drinking water standards. This would give the community a drought-proof water resource.

The local water district is about to launch a major campaign to encourage taxpayers to pass a $300,000,000 bond issue to support the installation of a new reverse osmosis purification system at the Water Pollution Control Plant. Public opinion polls show that only 30% of the voters favor using *recycled water* as a drinking water source. The local water district has hired your advertising agency to develop the print advertisements for this campaign.

To help develop your ad, discuss the following questions:

1. What's the name of your advertising agency?

2. Who is your target audience? (Be more specific than just the general public. Focus on a particular sector, such as new voters, mothers of school age children, restaurants, etc.)

3. What's your target audience's perception of using recycled water for drinking purposes?

4. What message do you need to communicate to that audience?

5. Who does that audience believe as a credible source of information (e.g. politicians, environmentalists, scientists, business leaders, their peers?)

6. What approach will you use? (Think about the tone of the ad, e.g., whether you plan to use testimonials, doomsday language, statistics, etc.)

7. What's the slogan for the campaign?

8. What's the headline for the advertisement?

9. What images will you use?

10. What will the body copy of the ad say?

Name:_____ Class:_____ Date:_____

After your group has written answers to all of the questions on the previous page, fill in the summary of your advertising approach below.

SUMMARY

Our print advertisement will _____

(convince/persuade/communicate to /remind/_____?)

_____

(specific target audience)

that using recycled water for drinking water purposes

_____ _____

(is/will/provides) (benefit)

3.6 PUBLIC OPINION SURVEY

Objective:

Students will be able to conduct a public opinion survey on water issues and graph and analyze their results.

Materials:

- *Public Opinion Survey Questions* student worksheet
- *Graphing the Survey Data* student worksheet
- *Analyzing the Survey Data* student worksheet
- graph paper or computer spreadsheet program

California Content Standards:

Mathematics, Grade 6

Identify different ways of selecting a sample ... and which method makes a sample more representative for a population (Statistics, Data Analysis, & Probability 2.2)

Analyze data displays and explain why the way in which the question was asked might have influenced the results obtained and why the way in which the results were displayed might have influenced the conclusions reached. (Statistics, Data Analysis, & Probability 2.3)

Identify data that represent sampling errors and explain why the sample (and the display) might be biased. (Statistics, Data Analysis, & Probability 2.4)

Identify claims based on statistical data and, in simple cases, evaluate the validity of the claims. (Statistics, Data Analysis, & Probability 2.5)

California Content Standards:

(Continued)

Science, Grade 6

Construct appropriate graphs from data and develop qualitative statements about the relationships between variables. (Investigation & Experimentation 7c)

Mathematics, Grade 7

Know various forms of display for data sets; ... use forms to display a single set of data or to compare two sets of data. (Statistics, Data Analysis, & Probability 1.1)

Science, Grade 7

Communicate the logical connection among hypotheses, science concepts, tests conducted, data collected, and conclusions drawn from the scientific evidence. (Investigation & Experimentation 7c)

Communicate the steps and results from an investigation in written reports and oral presentations. (Investigation & Experimentation 7e)

English–Language Arts, Grade 8

Create compositions that establish a controlling impression, have a coherent thesis, and end with a clear and well-supported conclusion. (Writing 1.1)

Establish coherence within and among paragraphs through effective transitions, parallel structures, and similar writing techniques. (Writing 1.2)

Write research reports. (Writing 2.3)

BACKGROUND

Conducting public opinion surveys is a standard tool that market researchers use to help their clients (politicians, public and non-profit agencies, corporations, etc.) determine public response to topical political, social, and consumer issues. After market researchers analyze the survey results, their clients learn how to position themselves more advantageously regarding a particular issue or product. In this student survey activity, your class will learn more about how people in their community view using recycled water as part of a drinking water supply. This activity can be used before the class develops advertisements to promote *potable* use *recycled water* in *3.5 Sell It, Baby!*

PROCEDURE

1. Discuss the purpose of public opinion surveys with the class and have them list examples of surveys, e.g. Neilsen ratings, Gallup poll, Harris poll, US Census, etc.
2. Tell them that each of them will conduct a public opinion survey on water issues by interviewing 10 people and compiling the responses on a chart. Be sure to discuss safety issues with the students. They can interview people they already know: friends, family, neighbors, other students. If they decide to go door-to-door, it may be best for them to pair up or go with an adult.
3. Distribute the *Public Opinion Survey Questions* and review the instructions with the students. Ask them to compile the survey information as a homework assignment.
4. As a class, compile all the data from every student on a master chart like the one on the *Graphing the Survey Data* worksheet.
5. Distribute the *Graphing the Survey Data* worksheet and have students copy the master chart for themselves. Then have them complete the graphing activity using either graph paper or an electronic spreadsheet program on the computer.
6. Discuss the graphs as a class. Ask them if they see any patterns or correlations in the responses.
7. Distribute the *Analyzing the Survey Data* worksheet and review the instructions with them. Have them complete the assignment for homework using their previously drawn graphs.
8. Have students share their hypotheses with the class. Discuss whether their hypotheses are substantiated by the data. Discuss the concept of bias in interview questions. *(See the following website for more background on evaluating public opinion surveys: http://www.sfasu.edu/polisci/Abel/PollEvaluation.html)*

Extension

1. Have students research different types of public opinion surveys on the Internet. Divide class into small groups and have them develop surveys on their own topics of interest. Have them graph and analyze the results as in the water survey.
2. More advanced classes can use the collected data as a launching point to learn about variance and standard deviation.

Public Opinion Survey Questions

STUDENT PROCEDURES

1. Ask 10 people, who live in Santa Clara County and have not answered these questions, to participate in your survey. Remember to be objective and polite. Don't argue. Also, say please and thank you.
2. Begin by saying, *I am doing a survey about local water use for my science class. May I ask you six questions?* You may prefer to have the respondent read the questions and provide you with the answers orally.
3. Using the chart on the next page, fill in all the responses of your participants, then tally each column total.

SURVEY QUESTIONS

1. What is your highest level of education?

   ❒ K-5 ❒ 6-8 ❒ 9-12 ❒ college student ❒ BA ❒ MA ❒ Ph.D

2. Do you drink bottled water at home? ❒ YES ❒ NO

3. Do you recycle or conserve fresh water at home? ❒ YES ❒ NO

   (Examples: short showers, ultra low-flush toilets, use a carwash, drip irrigation, or fountains/ponds that recirculate water)

4. I would like you to consider two facts before answering this next question:
   - First, at this time, recycled water does not reach the newest areas of fast-growing Santa Clara County.
   - Second, increased use of recycled water at parks, schools, medians, and public gardens will help restore populations of endangered species such as migrating birds, the migrating monarch butterfly and residents such as the California clapper rail and the salt marsh harvest mouse, all of which depend on the wetlands and San Francisco Bay for food, shelter, and to raise their young.

   Now the question:

   Are you in favor of paying higher taxes yourself to build more pipelines for recycling fresh water?

   ❒ YES ❒ NO

5. If recycling more fresh water also resulted in a lower water bill, are you now in favor of paying higher taxes yourself to build more pipelines for recycling fresh water?

   ❒ YES ❒ NO

6. If clean and safe recycled fresh water was made available for home use, resulting in an even lower water bill, would you drink the recycled water?

   ❒ YES ❒ NO

Ed. Level	**Q #1** YES	NO	**Q #2** YES	NO	**Q #3** YES	NO	**Q #4** YES	NO	**Q #5** YES	NO
K-5										
6-8										
9-12										
In College										
B.A.										
M.A.										
Ph. D.										
Column Totals										

Graphing the Survey Data

STUDENT PROCEDURES

1. Gather the results of the entire class. Then fill in the chart below:

Ed. Level	Q #1 YES	Q #1 NO	Q #2 YES	Q #2 NO	Q #3 YES	Q #3 NO	Q #4 YES	Q #4 NO	Q #5 YES	Q #5 NO
K-5										
6-8										
9-12										
In College										
B.A.										
M.A.										
Ph. D.										
Column Totals										

2. Make 5 *stacked bar charts* (1 graph for each question). A *stacked bar chart* is easier than a *pie chart* because you do not have to calculate percentages.
3. How to make the stacked-bar chart:
   - Label the x-axis, *education level.*
   - Label the y-axis, *number of responses*.
   - Make a color key: use 1 color for *Yes* and a different color for *No*.
   - Make 1 bar for each education level. Divide the bar per the *Yes* and *No* responses.
   - To be consistent, place all *Yes* responses on top of the *No* responses.

Analyzing the Survey Data

STUDENT PROCEDURES

1. Consider the responses to Question #6 regarding people's willingness to drink recycled water.

2. Think about assumption(s) you had about who would answer *Yes* or *No.* (Each assumption presents one hypothesis you had before you conducted the survey.)

   Example: Joe Smith assumed that anyone, regardless of education level, who answered *No* to Q#1 and *Yes* to Q#2 would drink *recycled water* and answer *Yes* to Q#6, because the person would trust his/her current water supply now and will continue to have no fear.

3. Now write an essay addressing the following points:

   - What's one hypothesis that will be supported by the class data?

   - Justify your hypothesis by writing a description of any patterns and/or correlation you observe by comparing and contrasting the graphs you drew.

   - Do an error analysis by describing how the public opinion survey can be made more reliable/ accurate/believable.